Claims

What is claimed is:

1. A cooling system comprising:

a thermal spreader having an inner chamber at least partially filled with a liquid;

a phase separator disposed within the thermal spreader and at least partially dividing the inner chamber into a boiling section and a condensing section, wherein the phase separator allows vapor and liquid to circulate between the boiling section and the condensing section;

a heat extraction assembly disposed at least partially within the inner chamber of the thermal spreader to extract heat therefrom, thereby facilitating condensing of vapor within the inner chamber to liquid; and

wherein when the thermal spreader of the cooling system is coupled to a heat generating component with the boiling section thereof disposed adjacent to the heat generating component, liquid within the thermal spreader boils in the boiling section, producing vapor which leaves the boiling section and causes liquid to flow into the boiling section from the condensing section, thereby providing circulatory vapor and liquid flow between the boiling section and the condensing section and facilitating removal of heat from the heat generating component.

2. The cooling system of claim 1, wherein the heat extraction assembly comprises fins disposed within the inner chamber, the fins facilitating condensation of vapor to liquid within the inner chamber.

3. The cooling system of claim 2, wherein the fins comprise pin fins disposed within the inner chamber of the thermal spreader, the pin fins residing in at least one of the condensing section and a vapor expansion section of the inner chamber.

4. The cooling system of claim 3, wherein the heat extraction assembly further comprises heat ejection pin fins extending from a surface of the thermal spreader and disposed outside of the thermal spreader.

5. The cooling system of claim 4, further comprising air flow means for inducing air flow across the heat ejection pin fins extending from the thermal spreader.

6. The cooling system of claim 4, wherein the pin fins within the inner chamber extend through the surface of the thermal spreader to comprise the heat ejection pin fins extending from the surface of the thermal spreader.

7. The cooling system of claim 3, wherein at least some pin fins within the inner chamber of the thermal spreader have different lengths within the chamber.

8. The cooling system of claim 7, wherein the pin fins reside in both the condensing section and the vapor expansion section, with the pin fins disposed within the vapor expansion section being longer than the pin fins disposed within the condensing section of the inner chamber.

9. The cooling system of claim 1, wherein when the thermal spreader of the cooling system is coupled to the heat generating component, the thermal spreader is disposed with a center axis thereof aligned within a range of $\pm 10^{\circ}$ of a vertical orientation.

10. The cooling system of claim 9, wherein the thermal spreader has a main surface with a surface area larger than a surface area of a surface of the heat generating component to which the thermal spreader is to be coupled.

11. The cooling system of claim 9, wherein when the thermal spreader of the cooling system is coupled to the heat generating component, the heat generating component is aligned to a lower region of the thermal spreader.

12. The cooling system of claim 1, wherein the heat generating component comprises at least one of an electronics device and an electronics module.

13. The cooling system of claim 1, wherein pressure within the inner chamber is lower than atmospheric pressure surrounding the cooling system.

14. A cooled electronics assembly comprising:

an electronics device or module having a main surface;

a cooling system coupled to the main surface of the electronics device or module, said cooling system comprising:

a thermal spreader having an inner chamber at least partially filled with a liquid;

a phase separator disposed within the thermal spreader and at least partially dividing the inner chamber into a boiling section and a condensing section, wherein the phase separator allows vapor and liquid to circulate between the boiling section and the condensing section;

a heat extraction assembly disposed at least partially within the inner chamber of the thermal spreader to extract heat therefrom, thereby facilitating condensing of vapor within the inner chamber to liquid; and

wherein the boiling section of the thermal spreader is disposed adjacent to the electronics device or module, and liquid within the thermal spreader boils in the boiling section with operation of the electronics device, producing vapor which leaves the boiling section and causes liquid to flow into the boiling section from the condensing section, thereby providing circulatory vapor and liquid flow between the boiling section and the condensing section and facilitating removal of heat from the electronics device or module.

15. The cooled electronics assembly of claim 14, wherein the heat extraction assembly comprises fins disposed within the inner chamber, the fins facilitating condensation of vapor to liquid within the inner chamber.

16. The cooled electronics assembly of claim 15, wherein the fins comprise pin fins disposed within the inner chamber of the thermal spreader, the pin fins residing in at least one of the condensing section and a vapor expansion section of the inner chamber.

17. The cooled electronics assembly of claim 16, wherein the heat extraction assembly further comprises heat ejection pin fins extending from a surface of the thermal spreader and disposed outside of the thermal spreader.

18. The cooled electronics assembly of claim 17, further comprising air flow means for inducing air flow across the heat ejection pin fins disposed outside the thermal spreader.

19. The cooled electronics assembly of claim 16, wherein the pin fins reside in both the condensing section and the vapor expansion section, with the pin fins disposed in the vapor expansion section being longer than the pin fins disposed within the condensing section of the inner chamber.

20. The cooled electronics assembly of claim 14, wherein the thermal spreader of the cooling system coupled to the electronics device or module has a center axis aligned within a range of $\pm 10^{o}$ of a vertical orientation.

21. The cooled electronics assembly of claim 14, wherein pressure within the inner chamber is lower than atmospheric pressure surrounding the cooling system.

22. A method of fabricating a cooling system for a heat generating component, said method comprising:

providing a thermal spreader having an inner chamber and a phase separator disposed therein, the phase separator at least partially dividing the inner chamber into a boiling section and a condensing section and allowing vapor and liquid to circulate between the boiling section and the condensing section, the thermal spreader further including a heat extraction assembly disposed at least partially within the inner chamber to extract heat therefrom;

at least partially evacuating the inner chamber and at least partially backfilling the inner chamber with a liquid; and

wherein when the thermal spreader of the cooling system is coupled to a heat generating component with the boiling section thereof disposed adjacent to the heat generating component, liquid within the thermal spreader boils in the boiling section, producing vapor which leaves the boiling section and causes liquid to flow into the boiling section from the condensing section, thereby providing circulatory vapor and liquid flow between the boiling section and the condensing section and facilitating removal of heat from the heat generating component.

23. The method of claim 22, wherein the at least partially evacuating comprises producing subatmospheric pressure within the inner chamber of the thermal spreader with the liquid at least partially filling the inner chamber, thereby facilitating boiling of the liquid within the inner chamber at a lower temperature than at atmospheric pressure.

24. The method of claim 22, wherein the heat extraction assembly comprises fins disposed within the inner chamber, the fins facilitating condensation of vapor to liquid within the inner chamber.

25. The method of claim 24, wherein the fins comprise pin fins disposed within the inner chamber of the thermal spreader, the pin fins residing in at least one of the condensing section and the vapor expansion section of the inner chamber.

26. The method of claim 25, wherein the heat extraction assembly further comprises heat ejection pin fins extending from an outer surface of the thermal spreader.

27. The method of claim 26, further comprising providing air flow across the heat ejection pin fins outside of the thermal spreader for facilitating dissipating of heat when the thermal spreader of the cooling system is coupled to a heat generating component.

28. A method of cooling an electronics device or module comprising:

providing a cooling assembly, the cooling assembly comprising:

a thermal spreader having an inner chamber at least partially filled with a liquid;

a phase separator disposed within the thermal spreader and at least partially dividing the inner chamber into a boiling section and a condensing section, wherein the phase separator allows vapor and liquid to circulate between the boiling section and the condensing section; and

a heat extraction assembly disposed at least partially within the inner chamber of the thermal spreader to extract heat therefrom, thereby facilitating condensing of vapor within the inner chamber to liquid; and

coupling the cooling system to a main surface of the electronics device or module, with the electronics device or module disposed adjacent to the boiling section of the thermal spreader, wherein liquid within the thermal spreader boils in the boiling section with operation of the electronics device or module, thereby producing vapor which leaves the boiling section and causes liquid to flow into the boiling section from the condensing section, thereby providing circulatory vapor and liquid flow between the boiling section and the condensing section and facilitating removal of heat from the electronics device or module.

29. The method of claim 28, further comprising disposing the cooling system so that a center axis of the cooling system is aligned within a range of $\pm$ 10° to a vertical orientation, thereby allowing gravity to facilitate circulation of the liquid flow between the condensing section and the boiling section.

30. The method of claim 28, wherein the heat extraction assembly comprises pin fins disposed within the inner chamber of the thermal spreader residing in both the condensing section and a vapor expansion section of the inner chamber, and wherein the heat extraction assembly further comprises heat ejection pin fins extending from an outer surface of the thermal spreader.

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